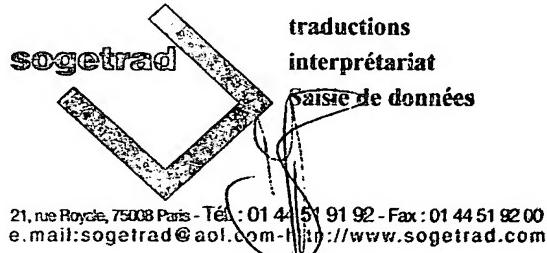


## TRANSLATION CERTIFICATE

We, SOGETRAD SARL – 21 rue Royale, F-75008 PARIS, hereby certify and attest that this translation was made by a translator whose native tongue is English, and who has a perfect knowledge of the French language, and that this translation is true and sincere as far as he knows,

AND

we make this declaration conscientiously believing the statement contained herein to be true in every particular.



Signed in Paris, France  
on March 11, 2004

## **Address sequencing in a domain name server**

This invention relates to telecommunication networks, and in particular  
5 those using the IPv6 (Internet Protocol, version 6) protocol stack. More precisely,  
it concerns the resolution of addresses in a domain name server associated with  
such telecommunication networks.

Such domain name servers are well known in the state of the art, and are  
conventionally known as Domain Name Servers or DNS. The operation of the  
10 DNS is standardised and described in RFCs 1034 and 1035 of the IETF (Internet  
Engineering Task Force).

The purpose of domain name servers is to simplify addressing within an IP  
telecommunication network. They behave like telephone directories, associating  
the symbolic names of network elements (or domain names), which represent no  
15 reality in the network, with the numerical addresses of these network elements.

Thus, when a first network element wants to address a data stream to a  
second network element, it can use either the address of this second network  
element, if it is known, or the symbolic name of this second element.

In this latter case, the first network address element sends a request  
20 containing this symbolic name to the domain name server. In return, it receives  
the numerical address or addresses corresponding to this symbolic name. It can  
also send the data stream to the second network element using its address.

However, a problem arises when a single domain name is associated with  
several addresses. This is the case in particular in a network employing the IPv6  
25 protocol stack, where the IPv6 specifications actually allow the association of

several addresses with a single network element.

The use of a DNS system in an IPv6 type network is described in RFC 1886 of the IEFF, entitled "*DNS Extensions to Support IP Version 6*".

These addresses can be addresses of different levels. As described in  
5 RFC 2373 of the IEFF, entitled "*IP version 6 Addressing Architecture*", there exist  
different types of address, differentiated on the basis of a prefix. There are  
therefore addresses with a global value, and addresses with a local value,  
particularly local to a site. When the sender and the recipient of the data stream  
are located in a single addressing space (a site), it is best to use a local address  
10 proper to this addressing space. This type of address local to a site will later be  
referred to also as a site address.

In any other case, the global address should be used, because otherwise  
the data stream cannot be correctly routed to the recipient.

If the global address is always used, then the data streams will be routed  
15 correctly, but use of the network will not be optimal. Moreover, no guarantee is  
given regarding whether the data streams will ever leave the site.

It is possible to have addresses of different natures, like an IPv6 address  
and one known as a "6to4" address, for example, as described by RFC 3056 of  
the IETF, entitled "*Connection of IP Domains via IPv4 Clouds*".

20 This is one of the mechanisms used for the gradual migration of an IPv4  
type network to an IPv6 type network.

The "6to4" mechanism allows purely IPv6 network elements to  
communicate with other IPv6 network elements via purely IPv4 network  
elements. In order to achieve this, a particular type of addresses, known as "6to4  
25 addresses", is defined. The addresses of this type are recognisable by the

network elements because they begin with the prefix "2002". Thus on receipt of a packet bearing such an address, a network element at the edge of the IPv6 site is able to encapsulate it in an IPv4 packet so that it can get it to its destination.

Use of the wrong address could lead to receipt of an IPv6 address by a  
5 network element which is compatible with IPv4 only, or indeed to an unacceptable limitation of the addressing space. The result would be failure to route the data stream.

In these two situations, a single name is associated with several addresses. The domain name server therefore sends all of these addresses as  
10 its response to a request, and the network element which has sent the request arbitrarily uses any of these addresses.

Now in the first situation, the use of an inappropriate address is not optimal from the network viewpoint.

Furthermore, in the second situation, the use of an inappropriate address  
15 may not allow correct addressing of the network element one wishes to reach.

There exist solutions which consist of sequencing the addresses, or indeed of assigning choices of different addresses according to certain criteria, but these solutions consist of performing the choosing or the sorting at the level of the applications. Such solutions are described, for example, in the document  
20 entitled "draft-ietf-ipngwg-default-addr-select-05.txt" dated 4 June 2001.

However, such a solution overloads the applications and, by allowing them too much freedom, can give rise to incorrect behaviour patterns in the whole of the communication network. In addition, an application may not have sufficient sight of the network in order to enable it to choose the optimum address. Finally,  
25 such a solution does not allow the deployment of an overall network

management policy.

The aim of the invention is to overcome the drawbacks of the current state of the art, by allowing the network element sending out a data stream to use the most effective and optimum address.

To this end, the subject of the invention is a domain name server associated with a data network, which include:

- means for receiving requests containing a domain name, and
- means for returning a response, containing one or more addresses associated with a domain name, to the sender of the request.

According to the invention, this domain name server is characterised in that this address, or these addresses, are sequenced by the domain name server inside the response.

According to one embodiment of the invention, this sequencing is effected as a function of the content of the request.

Sequencing can also be effected according to the topology of the network, where the most local address allowing one to address both the said sender of the request, and the network element corresponding to the domain name, is inserted first.

Sequencing can also be effected so that in the event of the presence of an IPv4 cloud between the sender of the requests and the network element corresponding to the domain name, and address of the "6to4" type is inserted first.

The invention and its advantages will appear more clearly in the description which follows below, together with the appended figures:

- Figure 1 illustrates a first implementation of the invention.

- Figure 2 represents a second implementation of the invention.

Figure 1 illustrates a network element composed of two sites (S and S').

Site S contains network elements  $R_1$ ,  $R_2$  and  $R_3$ , and site S' contains network element  $R_4$ .

5 As mentioned previously, there are different types of IPv6 addresses, which can be distinguished by different prefixes.

Among these address types, there are site-local addresses (or site addresses) and global addresses.

A site-local address is recognised because it is of the form "FEC0::/10",  
10 which means that the first 10 bits have the value FEC0 and the following 118 represent the addressing space proper. Similarly, a local link address is recognised because it is of the form "FE80::/80".

As a result, network element  $R_4$ , for example, can have a global address  $a_g$  and a site-local address  $a_s$ . This global address  $a_g$  can be like that defined in  
15 RFC 2374, entitled "*An IPv6 aggregatable Global Unicast Address*". This allows network element  $R_4$  to enter into communication with network elements located at other sites, such as, for example, network element  $R_1$  located at site S.

Let us assume that network element  $R_1$  wants to transmit a data stream to network element  $R_4$ .

20 To this end, it sends a request R to domain name server D, containing the symbolic name or domain name of network element  $R_4$ .

According to the invention, domain name server D is able to sequence the different addresses of the wanted network element in the response provided to the sender of the request R.

25 To this end, it can use information contained in this request R. Among this

information, in particular, is the source address of the request, that is the address of network element  $R_1$ . Knowing the addresses of network elements  $R_1$  and  $R_4$ , as well as the topology of the network, the domain name server is then able to determine the type of address to be used. In the present example, it is able to 5 determine that network elements  $R_1$  and  $R_4$  are not located at the same site, and therefore that the local address must not be used.

Disregarding other possible addresses, the server D therefore sequences the addresses in the order  $a_g \ a_s$  in the response  $R'$  which it is sending to network element  $R_1$ .

10 On receipt of this response  $R'$ , network element  $R_1$  is able to determine the address to use by selecting the first in the sequence, namely address  $a_g$ . It can then use address  $a_g$  to insert as the destination address in the data stream packets F which it is transmitting to network element  $R_4$ .

Without this sequencing, performed by the domain name server D, 15 network element  $R_1$  would have no means of determining the address that it must use. It might then have used the local address  $a_L$ , which would have led, in this case, to failure to route the data stream F.

In other words, the sequencing performed by the domain name server D is effected as a function of the request. If the source address of the request is a 20 local address, and if the name requested has a local address, it is the local address which will be sent first.

In general, what is involved is inserting the most local address in the first position, thereby enabling the addressing of both the sender (here network element  $R_1$ ) of request R and the network element corresponding to the wanted 25 domain name (here network element  $R_4$ ).

If network element  $R_1$  wishes to transmit a data stream to network element  $R_3$ , the domain name server sends its site-local address first (if it exists), so that network element  $R_1$  can use this in its communications with  $R_3$ .

Figure 2 illustrates a second implementation of the invention in the context  
5 of a heterogeneous network composed of IPv4 network elements and IPv6 or  
IPv4/IPv6 network elements.

Various mechanisms exist. In this example, the “6to4” mechanism is used.  
However, the invention is designed to apply to different mechanisms from the  
moment when different addresses are necessary.

10 In this example, a data network is composed of two domains  $N_A$  and  $N_B$   
separated by a cloud  $N_4$ , composed only of IPv6 network elements. This example  
illustrates the normal case of two sites which have migrated to the IPv4  
technology, and which are connected via a third network by a telecommunication  
operator, not yet having migrated and still compatible only with the IPv4  
15 protocols.

Network elements A and B are routers connecting cloud  $N_4$  to domains  $N_A$   
and  $N_B$  respectively.

In each of the domains,  $N_A$  and  $N_B$ , we have a domain name server (or  
DNS),  $D_A$  and  $D_B$  respectively. It is assumed that the two servers,  $D_A$  and  $D_B$ , are  
20 suitably configured, and mutually possess their correct address.

In a first stage, the sending network element x, wanting to transmit a data  
stream to a recipient network element Y, located in domain  $N_B$ , sends a request  
R to domain name server  $D_A$  associated with domain  $N_A$ . This request R contains  
the symbolic name of the recipient Y, and contains a source address which is an  
25 address of the sender x.

On receipt of this request R, server D<sub>A</sub> determines whether it possesses an association between the symbolic name contained in the request and an address. Since the recipient is outside domain N<sub>A</sub> "controlled" by server D<sub>A</sub>, this association does not appear in the tables or in the database of server D<sub>A</sub>.

- 5 According to a recursive configuration, it transmits the request to the domain name server D<sub>B</sub> of domain N<sub>B</sub>.

Since the recipient Y and the server D<sub>B</sub> form part of the same domain N<sub>B</sub>, the latter possesses the information relating to the recipient Y and to the association of its (symbolic) domain name and its addresses. In this example, the 10 recipient Y possesses at least two addresses:

- an a<sub>v6</sub> address which conforms to the IPv6 protocol which allows network element Y to communicate with the other network elements of domain Y or with network elements of other IPv6 domains (not shown),
- an a<sub>6to4</sub> address which conforms to the "6to4" technology mentioned previously, allowing the communication of two IPv6 network elements via an IPv4 cloud.

According to the invention, domain name server D<sub>B</sub> sequences the two (or more) addresses corresponding to the symbolic name of the wanted network element Y.

20 Sequencing can be effected as a function of the content of the request transmitted by domain name server D<sub>A</sub>. In fact this request contains the address of the sender (domain name server D<sub>A</sub>), which allows domain name server D<sub>B</sub> to determine that since the source address is one of the "6to4" type, then "6to4" technology should be used.

25 It is therefore able to determine that the relevant address is the a<sub>6to4</sub>

address of the recipient Y, and as a consequence, it is able to sequence the various addresses by putting the most relevant address  $a_{6to4}$  (the "6to4" address of recipient Y) first, and inserting these sequenced addresses in a response R'.

This response is then sent to domain name server  $D_A$ , which is then able  
5 to respond to the request from the sender x.

According to the invention, this sender is capable of interpreting the sequence of addresses in the response R'. This interpretation can consist of simply using the first address contained in the response. This first address is the  $A_{6to4}$  address, which is compatible with the "6to4" mechanism.

10 The sending network element x can then use the  $a_{6to4}$  address to address the data stream to the recipient network element Y. This data stream F will traverse network elements A and B and cloud  $N_4$ , being routed correctly.

In other words, the sequencing performed by the domain name server  $D_B$  is effected in such a manner that in the case of the presence of an IPv4 cloud  
15 (here  $N_4$ ) between the sender of the request (here X) and the network element corresponding to the domain name contained in the request (here Y), and address of the "6to4" type (here  $a_{6to4}$ ) is inserted first.

It is as a result of this sequencing effected by the domain name server  $D_B$  that the sending network element x is able to determine the  $a_{6to4}$  address to be  
20 used.